BIROn - Birkbeck Institutional Research Online

Nadeau, Pierre (2011) Innovation and venture capital exit performance. Strategic Change: Briefings in Entrepreneurial Finance 20 (7-8), pp. 233-252. ISSN 1099-1697.

Downloaded from: https://eprints.bbk.ac.uk/id/eprint/4587/

Usage Guidelines:
Please refer to usage guidelines at https://eprints.bbk.ac.uk/policies.html or alternatively contact lib-eprints@bbk.ac.uk.

BIROn - Birkbeck Institutional Research Online

Enabling open access to Birkbeck's published research output

Innovation and venture capital exit performance

Journal Article

http://eprints.bbk.ac.uk/4587

Version: Submitted (Unrefereed)

Citation:

Nadeau, P. (2011)
Innovation and venture capital exit performance –
Strategic Change: Briefings in Entrepreneurial Finance 20(7-8), pp.233-252

© *2011* Wiley Blackwell

Publisher version

All articles available through Birkbeck ePrints are protected by intellectual property law, including copyright law. Any use made of the contents should comply with the relevant law.

Deposit Guide

Contact: lib-eprints@bbk.ac.uk

INNOVATION AND VENTURE CAPITAL EXIT PERFORMANCE

A paper

presented by

Dr Pierre Nadeau
Birkbeck University of London
Malet Street, London

for

Strategic Change: Briefings in Entrepreneurial Finance

INCREASING PROFITABILITY WITH ENTREPRENEURIAL FINANCE

Autumn 2011

Innovation and Venture Capital Exit Performance[1][2]

Pierre Nadeau
Birkbeck University of London
Malet Street, London WC1E 7HX

August 2011

Abstract

Venture capital is a potent source of R&D financing which contributes significantly to technological innovation output in the form of patented inventions. Scholars have argued that tighter protection of intellectual property rights reduces expropriation risks and encourages venture capitalists to invest in technology firms. Prior studies have showed that early stage technology investors give much weight to investment selection criteria related to innovation e.g. protection of intellectual property, platform and uniqueness. However, VC investors generally receive little on their investments until a liquidation event occurs – IPO and M&A (trade sale) exits define venture capital performance.

A review of the literature indicates that few empirical studies have examined the influence of patented innovation on the exit performance of VC-backed technology firms. This paper seeks to address this specific knowledge gap in venture capital research and practice. It builds on resource-based view (RBV) theory which argues that technological innovation is an important strategic resource of the entrepreneurial firm that can attract VC investment, provide competitive advantage and produce superior performance.

This study is based on matched data compiled from VentureXpert™, Delphion™ and NBER/USPTO databases. The resulting unique and proprietary dataset consists of 1504 U.S. VC-backed exits across 7 technology sectors in the 20 years from 1980-2000, 961 IPOs and 543 M&As. The influence of technological innovation on the exit performance of VC-backed technology firms is examined. As predicted by RBV theory, technology firms engaged in patenting activity were found more likely to be associated with the more profitable IPO exit route, higher VC investment and exit value.

[1] JEL classification codes: G24, G32, M13, O31, O32.
[2] Colleagues at Birkbeck supplied useful comments. In particular, I thank Carlo Milana and Helen Lawton-Smith for their suggestions. I gratefully acknowledge research funding from Birkbeck College Research School.

1. Introduction

In recent times the subject of innovation has drawn significant interest amongst economists, policy makers and academia. The interest stems from the Schumpeterian belief that technological competition is the major form of competition under capitalism. Innovation is crucial for long-term economic growth and a powerful explanatory factor behind differences in performance between firms, regions and countries. Studies after studies have shown that firms that succeed in innovation prosper, at the expense of their less able competitors (EIU, 2007). R&D is considered a key source for sustaining economic growth and welfare and countries have set long-term targets for their R&D intensities. In particular, expansion of new firms in high-technology sectors has become essential in many advanced economies and it is therefore of utmost importance to ensure that the right conditions exist for “new technology-based firms” to flourish. Major differences, however, still persist. For example, early-stage venture capital investment (at 0.06% of GNP) is at a level in the US that is 60% higher than in the EU (EC DG Research, 2007). Consequently, the economic impact of venture capital (VC) on the U.S. economy is more significant. Global Insight (2007) estimated total revenue of some 24,000 U.S. venture-backed companies to be $2.3 trillion (17.6% of U.S. GDP) and total employment to be 10.4 million (9.1% of U.S. private sector employment). Economic necessity has become the mother of innovation.

Innovation is rightly considered a critical driver of economic growth and value creation, and venture capital an important channel through which innovation in technology venture firms is financed. Moreover, in developed finance and knowledge-based economies the evolution of the enterprise and its capacity to innovate depend on the limits defined by finance (Laperche et al, 2008). The relationship between innovation and finance is also coloured with some level of controversy. Whilst some authors asserted that venture capital spurs innovation (Kortum and Lerner, 2000) others claimed that venture capital actually thwarts innovation (Stuck and Weingarten, 2005). There is little doubt that the relationship between venture innovation and finance is an exciting field of study for researchers who wish to pay attention to it.

In particular, *exiting*, the final stage of the VC investment process is a most critical component of venture capital investment performance as VC-backed firms rarely produce positive cash flows for investors until a liquidity event occurs. From the investor’s perspective, liquidity events (“exits”) are only measure of performance in venture capital investing and IPOs and M&As are the most common form of venture capital exits. Going public (via an Initial Public Offering, IPO) and private sale of the venture to another firm (i.e. Merger and Acquisition, M&A) are, by far, the most common exit routes in the U.S. Thus in this study, technological innovation, with filed patents used as proxy, is examined to determine whether it influences the exit performance of VC-backed technology firms which exited via an IPO or an M&A.

Sector-specific studies have been limited to showing a relationship between patenting and (i) the total venture capital invested in technology firms (Baum and Silverman, 2004; Mann and Sager, 2007) and (ii) the likelihood of an IPO (Hsu and Ziedonis, 2007). However, there is no known large-scale empirical panel study, across multiple technology sectors, of the influence of patenting activity on venture capital exit performance. This is an important topic and scholars have rightly stressed how very little attention the exiting of venture capital investments has attracted Gompers and Lerner (2004, p.350). Moreover, O'Sullivan (2006) noted the lack of integration between the fields of finance and innovation as evidenced by the absence of empirical studies in this area. Zingales (2000) was also explicit in his call for "new foundations", in particular a more sophisticated analysis of the firm, for the study of corporate finance ("the way firms are financed"). With the rise of an economy increasingly driven by intellectual capital (Grandstrand, 1999) traditional corporate finance theory has revealed serious limitations. Zingales stated:

> "Understanding the factors underlying a firm's ability to exploit growth opportunities will not only affect the way we value firms but also create a fundamental building block toward a theory of entrepreneurship."

This empirical study seeks to address this specific knowledge gap in venture capital research and practice. It is based on matched data compiled from VentureXpert™ (venture data), Delphion™ and NBER/USPTO (patent data) databases. The resulting unique and proprietary dataset consists of 1504 U.S. VC-backed exits across 7 technology sectors, 961 IPOs and 543 M&As, which collectively filed 4,261 patents in the 20 years from 1980-2000.

Mean total VC investment, exit value and exit multiple over the study period were $22.0 million, $145 million and 21x, respectively. Mean total VC investment, exit value and exit multiple for firms which exited via an IPO were higher by 84%, 115% and 111% respectively, than for technology firms exiting via an M&A – making IPO the most attractive exit route over the study period. Results are consistent with prior studies (Metrick, 2007; Das, 2003). A larger percentage of venture firms which exited via an IPO engaged in patenting activity (52%) prior to exit than those which exited via an M&A (33%). The relationship holds true for all sectors but the semiconductor sector where mean patenting rates were not found to be significantly different between exit routes. After controlling for exit route, venture firms engaged in patenting activity prior to exit were still associated with a statistically significant increase in total VC investment and exit value. Patenting activity, however, had a negative influence on exit multiple. Patenting and venture capital performance indicators were found to vary significantly across sectors. Combined (M&A and IPO exits) patenting rates ranged from a low of 20% for the internet sector to a high of 76% for the semiconductor/electronics sector.

This empirical study builds on resource-based view (RBV) theory for explaining why patented innovation is associated with larger VC investment and exit value. Patented innovation is shown to be a critical resource of the firm which (i) helps reduce inherent selection risks associated with information asymmetry, can (ii) act an insurance policy by enabling VCs to recover some residual value in the event of a business failure and, more crucially, (iii) result in sustainable competitive advantage and superior performance for the new venture. The findings have important implications for venture capital practice as they confirm that protected inventions convey important information about the technology firm and its future prospects. They have and should continue to warrant considerable attention during the due diligence process.

In the next two sections the theoretical framework for the study is discussed and research hypotheses developed. It is followed with sections on data and methodology, results and conclusion.

2. Resources of the Firm

The *resource-based view* (RBV) of the firm, suggesting that the returns earned by firms could largely be attributed to resources they held, find its origins more than fifty years ago (Penrose, 1959). It took, however, 25 years for strategic management scholars to recognise the power of Penrose's theory of the firm (Wernerfelt, 1984). In his seminal paper *Firm Resources and Competitive Advantage*, Barney (1991) identified four empirical indicators of the potential of the firm resources to generate sustained competitive advantage – *value*, *rareness*, *imitability* and *substitutability* (VRIS). Moreover, Barney's model assumes heterogeneity between resources the firm controls and that these resources are not perfectly mobile across firms, implying that heterogeneity can be long lasting. According to RBV, *resources* (e.g. assets, capabilities, processes, information, knowledge, etc) are defined as strengths firms can use to conceive strategies and *sustained competitive advantage* as something the firm has when it is implementing a unique value creating strategy not reproducible by current or potential competitors (in spite of their effort to do so). Whenever these conditions hold, the firm's bundle of resources can assist the firm sustaining superior performance.

Some strategy authors believe that *intangible resources*, because they are socially complex and more difficult to understand and imitate, are more likely to lead to a sustained competitive advantage than are tangible resources. This is an important concept as technology-based firms (TBFs) tend to be primarily endowed with intangible resources at an early stage. In particular, *knowledge* is a firm-specific intangible resource and possibly firm's most critical competitive resource (Grant, 1996). The knowledge-based approach helps shed new light upon firm's innovations. In the knowledge-based view (KBV) of the firm, the principle of *appropriability* (i.e. the ability of the owner of a resource to receive a return equal to the value created by that resource) defined earlier by Arrow (1959) is revisited - an issue of great concern for TBFs seeking to sustain technological innovation. Supporting the knowledge-based approach, Spender (1996) argued that knowledge and the firm's ability to generate it were at the core of the theory of the firm and provided further insights above and beyond RBV theories and competitive strategy theory. Accordingly, *technological knowledge* (that is, knowledge that describes the functions and interactions of natural and artificial things) can be individual explicit (i.e. individual skills pertaining to a particular technology that can be codified e.g. a patent), individual tacit (i.e. individual skills pertaining to a particular technology that is personal), collective explicit (e.g. standard operating procedures), or collective tacit (e.g. an organization's routines and culture regarding technology). Moreover, for innovation to occur, knowledge must not just be shared, but also reused, recombined, and accumulated (Murray et al., 2007). Each of the technological knowledge dimensions can be the source of competitive advantage and value creation.

However, in this study we investigate the evidence of superior venture capital performance resulting from firm's competitive advantage gained from a specific type of knowledge i.e. explicit technological knowledge, which can be codified, protected and measured. The innovation literature drawing on resource-based view theory, and the more specific knowledge-based view theory, are used here to horde theoretical underpinnings for this paper. It is argued that venture firms logically and rationally view technological innovation as a strategic resource from which they can derive a sustainable competitive advantage (Porter, 1979, 1985) and produce superior performance (Arrow, 1959; Griliches, 1981; Romer, 1986, 1990; Geroski, 1993; Granstrand, 1999).

The approach finds much support in the strategy literature which argues that technological learning plays a vital role in the firm's competitive success (Hitt et al. 2000, p.232):

> "Among the many factors that will influence the firm's performance in the 21st century's competitive landscape, globalization, technological advances and knowledge are perhaps the most significant."
>
> "To generate value, firms must be able to identify, create and continuously manage knowledge. Knowledge may be the most strategically significant resource the firm can possess and on which sustainable competitive advantages can be built. Some scholars believe that competition is becoming more knowledge-based and that the sources of competitive advantage are shifting to intellectual capabilities from physical assets."
>
> "The increasing competitive importance of knowledge has led to the development of the knowledge-based view of the firm. This evolving perspective, suggesting that the primary rationale for the firm's existence is to create, transfer and apply knowledge, is an extension of the resource-based view of the firm."

The innovation literature also proposes novel approaches for theorizing about technology-based firms by focusing on technology as part of the firm's intellectual capital and general resources, interacting within a competitive environment under active and innovative management (Granstrand, 1998). The knowledge resource shares the general characteristics of knowledge but with additional features such as being protectable by patents, giving them strong economies of scale, scope, speed and space resulting in a greater ability for the entrepreneurial technology firm to create a sustainable competitive advantage. Conversely, larger industrial groups can exercise alternative strategic options to expand their technology knowledge base. They can use their substantial financial resources to acquire dynamic technological capabilities via an M&A-based corporate expansion strategy. Patent studies have shown that, in contrast with market-motivated acquisitions, in technology-motivated acquisitions technological relatedness increased in inter-industry expansions (Cantwell and Santangelo, 2008). Moreover, previous research highlighted the interplay between venture capital and TBFs' innovation. Kortum and Lerner (2000) examined the influence of venture capital on innovation in the U.S. across twenty industries over three decades and found that increases in venture capital activity are associated with higher patenting rates. Whilst the ratio of venture capital to R&D was less than 3% authors venture capital accounted for more than 8% of industrial innovations during the period, implying that VC- backed firms are more likely to innovate and engage in patenting activity.

We may conclude that technological innovation is, arguably, one of the most potent resources the entrepreneurial technology-based firm (TBF) can have to sustain long term competitive advantage over large established incumbents, and in doing so, produce superior performance.

3. Financing Early Stage Technology-based Firms

Venture capital finance, also referred to as *entrepreneurial finance* by academia, is a major source of financing for technology entrepreneurs. Its study and understanding is important as the lack of financial management ability has been found to be a major cause of failure amongst venture firms (Thornhill and Amit, 2003). Early-stage venture capital investing is a risky business, characterised by high failure rates. Less than 25% of those firms which get a first round of VC funding manage to exit via an IPO, the most profitable exit route (Metrick, 2007). Thus, the chance that an investment's actual return will be different than expected is high. This includes the possibility of losing some or all of the original investment. A fundamental idea in finance is the relationship between risk and return. The greater the amount of risk that an investor is willing to take on, the greater the potential return. The average IRR (internal rate of return) for U.S. early-stage venture capital, well in excess of 30% during the 10 years ending 2007, is a testimony considering that Nasdaq and S&P500 indices achieved less than 5% during the period[3].

[3] Source: Thomson Financial/National Venture Capital Association.

The reason for this is that investors need to be compensated for taking on additional risks. Venture capital investment risks include technology risk, market risk, management risk, legal risk, financial risk and liquidity risk[4]. Technology venture finance differs from corporate finance in two important ways:

I. *Information Asymmetry*. Differences between venture and corporate finance also arise from the magnitude and importance of the information problem between inside and outside investors. This is compounded by the fact that in venture finance outside investors are looking specifically to the venture project to realise a return. This is in sharp contrast with the corporate setting, where "selling" specific projects to investors is not necessary as each project are usually small relative to the value of the corporation. There is abundant literature about the central role VCs play in minimizing information asymmetries (Amit et al., 1998). The structuring of staged venture capital investments is crucial when agency and monitoring costs exist. Expected agency costs have been found to increase as assets become less tangible, growth options increase, and asset specificity rises (Gompers, 1995). Venture capitalists are known to concentrate investments in early stage and high technology companies where informational asymmetries are highest. Technology investors give more weight to innovation criteria such as protection of intellectual property (IP), uniqueness and platform technology than "people" or "financial" investors (Clarysse et al., 2004). Decreases in industry ratios of tangible assets to total assets (i.e. increases in intangible intellectual property), higher market-to-book ratios, and greater R&D intensities lead to more frequent monitoring. Venture capitalists have been found to continuously gather information and maintain the option to discontinue funding projects with little probability of going public[5]. In practice, venture capital contracts which may include cash flow rights, board rights, voting rights, liquidation rights, and other control rights which are used by the entrepreneur and VC investors to realise the advantages of VC financing and mitigate agency costs and information problems (Admati and Pfleiderer, 1994; Kaplan and Stromberg, 2003). In particular the use of convertible securities (e.g. convertible preferred shares) with liquidation rights has been found to contribute to optimal exit decisions in venture capital finance (Bascha and Walz, 2001).

II. *Exiting*, the final stage of the VC investment process is a most critical component of valuation and evaluation in initial investment decisions. In corporate finance, investment opportunities

[4] Risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimize a loss.
[5] Guler (2007) however found that VCs were less likely to terminate unsuccessful investments as they participate in more rounds of financing.

> are evaluated based on ability to generate free positive cash flow. The free cash flow may be distributed to investors in the form of dividends or retained by the corporation to help finance other opportunities. Investing in new ventures is different. New venture investments normally are not liquid and often do not generate any significant free cash flow for several years. Thus, VCs evaluate opportunities based on the expectation of a liquidity event that will enable them to realise a return. Because of the importance of liquidity events, they are generally forecast and factored into valuation of the investment. Going public (via an Initial Public Offering, IPO) and private sale of the venture to another firm (i.e. Merger and Acquisition, M&A) are, by far, the most common exiting alternatives in the U.S. Giot and Schwienbacher (2007) found that IPOs and M&As represented between 84-95% of all exits depending on investment stage.

From the investor's perspective liquidity events ("exits") are the true and only measure of performance in venture capital investing and IPOs and M&As are the most common form of venture capital exits. Thus, this paper will closely examine the relationship between innovation and the IPO or M&A exit of technology ventures.

IPO and M&A Exit Options

There are many factors which may influence the ultimate choice of exit: IPO or M&A. *Financial*, *information*, and *timing* factors as well as market conditions are most often cited in the literature as contributing to the exit decision. Exit choices of venture-backed firms follow a performance hierarchy, with top-performing companies choosing IPOs, companies opting for trade sales performing less well on average. At the other end of the spectrum troubled investments often result in delayed exits or write-offs. In a random sample of 234 U.S. companies which received VC financing after 1996, Hege et al. (2006) computed a mean IRR of 404% for IPO exits and 156% for Acquisition exits. In a comparative study of U.S. and Canadian VC exits Cumming and MacIntosh (2003) also found a significant difference between the gross average real return of IPOs (465%) and Acquisitions (143%) asserting that IPOs were the preferred means of exit for highly valued firms, market conditions permitting. Thus, one might expect that VC-backed firms endowed with greater technology resources are more likely to be associated with IPO than M&A exits.

Hypothesis 1: Exit choice is associated with the innovation of technology-based firms.

The technology regime in different industries can affect the extent of knowledge asymmetries between different types of owners and thus the mode of exit for venture capitalists. Makri et al. (2007) suggested that the degree of technological diversification and technological cumulativeness of an industry will have a positive effect on the likelihood that a venture capital firm will exit its technology investment via an M&A as opposed to an IPO. Thus, we shall verify whether tested hypotheses hold across sectors.

There are few empirical studies which compared the timing characteristics of IPO and M&A exits. However, Giot and Schwienbacher (2007) provide an example of a thorough investigation of the dynamics of exit options for U.S. venture capital funds. Using a sample of 20,000 investment rounds, they applied survival analysis methods to study the time to 'IPO', 'trade sale' and 'liquidation' for 6000 VC-backed firms. Exit times were modelled using competing risks models, allowing for a joint analysis of exit type and exit timing. The hazard rates for IPOs were found to be non-monotonic with respect to time. VC-backed firms first exhibit an increased likelihood of exiting to an IPO until they reach a plateau whereby non-exited investments have fewer possibilities of IPO exits as time increases. In contrast the hazard rate of trade sale exits was found to be less time-varying. As expected, significant variations in exit time were found across sectors (Huyghebaert et al., 2004).

Building on agency and venture finance theory Chemmanur and Fulghieri (1999) developed a theory of going public. They postulated that firms have the choice between private equity financing and going public and argued that the optimal IPO timing decision was determined by the firm's trade-off between minimizing the duplication in information production by outsiders and avoiding the risk-premium demanded by venture capitalists. However, IPOs tend to come in unexplained waves, and cluster in time. Exit conditions are a key performance driver in venture financing. The more serious problem caused by the absence of an active IPO market for venture-backed companies has been viewed as perhaps the single most important reason for the late development of venture financing outside the U.S. Moreover, it is well known that the venture capital industry has a high volatility which is associated with shifting valuations and activity in public equity markets. Gompers et al. (2008) examined how changes in public market signals affected venture capital investing between 1975 and 1998 and concluded that venture capitalists with the most industry experience are best at adjusting investments to changes in public market signals (i.e. Tobin's q[6], IPO activity). Thus, in this study of venture capital exit performance it is important to control for temporal as well as sectoral effects.

IPO and M&A Exit Performance

Much has been written about the huge returns VCs can realise when a portfolio company goes public or is sold to a "motivated" strategic buyer. Successful exits are always well documented because they

[6] Tobin's q is a ratio comparing the value of a firm given by financial markets with the value of a firm's assets.

are required and expected to ensure the financial viability of investments in VC funds by limited partners (LPs). Individual VC exit multiples as well as the overall distribution of exit multiples are both critical to the success of VCs. One hugely successful exit will provide forgiveness for many portfolio company failures and, in the absence of such major success, a distribution of smaller successes may be acceptable to meet LPs' expected rate of return.

Metrick (2007) analysed state of the art panel data from the Sand Hill Econometrics (SHE) database and found that by ten years after the initial VC investment 23.2 percent of all companies had an IPO, 38.0 percent had been acquired, 14.3 percent were defunct, and 24.6 percent were still private. However, Woodward and Hall (2003) investigated companies "still private" ten years after initial VC financing and research confirmed that these companies were more likely to have shut down worthless than other companies. Although 61% of all VC investments ended in an exit, all were not equally "successful". Metrick found that 61.2 percent of all IPO exits yielded gross value multiples[7] (i.e. GVM before fees and carry) in excess of five times the original investment (i.e. early-stage or expansion) and 5.3 percent yielded multiples in excess of 50 times. However, the multiples for acquisitions were much lower with 38.1 percent of all acquisitions resulting in a loss. Results are consistent with those from a 1980-1997 study by Das et al. (2003) who found exit multiples for acquired firms (average 7x for early-stage investments) to be significantly lower than exit multiples for IPOs (average 16x for early-stage investments) over the same stage of financing, time period and in similar industries. These returns appear impressive at first but correcting for exit selection bias of IPO of acquisition the arithmetic return of VC investments are reduced to 59% with an alpha of 32%. This is not significantly different from those of comparable small public stocks, implying that venture capital returns are correlated with market returns (Cochrane, 2005).

The literature directly related to the research question of this paper is limited, sector-specific and has largely focused on the impact of innovation (proxy by patents) on VC financing and performance measures such as the occurrence of an IPO exit. Evidence of the influence of innovation on investment performance by venture capitalists is scarce. In a study of VC-backed semiconductor start-ups Hsu and Ziedonis (2007) found that a larger patent application stocks increased both the likelihood of achieving liquidity through an IPO. These findings are consistent with RBV and suggest that patents may be a strategic resource of that can provide competitive advantage and improve performance. Similarly, Mann and Sager (2007) linked and analysed data relating to venture capital financing of software start-up firms with data concerning the patents obtained by those firms and found significant and robust positive correlations between patenting and firm's performance including total VC investment and exit status. Patenting practices varied very considerably amongst sub-sectors of the software industry, suggesting the influence of sectoral factors.

In this study, hypotheses are formulated to test whether total VC investment prior to exit, exit value and exit multiple are associated with innovation (proxy by patenting activity) of technology-based firms. The filing of patents may signal to prospective VC investors that the technology-based firm (i) has matured sufficiently to consider the commercial exploitation of its technological innovation and (ii) it is prepared to invest in the protection of its technological innovation. To strategic buyers and IPO investors it may signal that the technology-based firm (i) has accumulated unique technology resources, and (ii) develop a sustained competitive advantage in the marketplace. These technology resources, in turn, reduce the investment risk as perceived by VC investors, strategic buyers and IPO investors. Sectoral and temporal effects are examined whether they account for the uneven distribution of patenting activity and key determinants of venture capital investment performance. Total VC investment is defined as the cumulative sum of all venture capital round financings prior to exit. Exit value is defined as the deal size for M&A transactions and post-offer value for IPOs. Exit multiple is defined as the ratio of the value of the firm upon exit to the total VC investment. Hypotheses are as follows:

Hypothesis 2: Total VC investment is associated with the innovation of technology-based firms.

Hypothesis 3: Exit value is associated with the innovation of technology-based firms.

Hypothesis 4: Exit multiple is associated with the innovation of technology-based firms.

4. Data & Methodology

The method of choice consists in the analysis of (private) cross-sectional archival data for U.S. VC-backed technology M&A and IPO firms and related patent information spanning the 20 years from 1980-2000. The period from 1980-2000 is particularly attractive as these were buoyant times (incl. four economic business cycles) for various innovative technologies such as networking, internet and biotechnology. Moreover the duration of the study period matches the patent term of 20 years from filing date which is the time protection generally granted from patents in the U.S.

The sample includes 1504 VC-backed U.S. technology firms across seven different sectors, 961 which exited via an IPO and 543 via M&A between 1980 and 2000. The focus on VC-backed technology exits means that this is a study of what successful technology firms and VC investors do. Data are issued from two distinct worlds for their ability to test hypotheses and draw inferences: the

[7] Metrick defined ‘value multiple’ as the ratio of the value of the firm upon exit to the original Series A financing.

world of venture capital and the world of patents. Whilst both of these are well established research fields in their own right few bridges exist that provide a dependable path between them. One of the main challenges of this study was to build solid bridges between the world of venture capital and the world of patents.

Patents as a measure of technological innovation

Patents (a measure of technological innovation output) offer an important means of acquiring information about technological change in firms. They have advantages and disadvantages that complement other widely-used indicators such as R&D (a measure of technological innovation input), trade in high-technology products, etc. Innovation surveys can also be useful but do not lend themselves to comparisons at the country or firm level. In contrast patents are found increasingly used to monitor innovations occurring within the firm and chart the direction and content of current innovative activities carried out by technology firms (Archibugi et al., 1996). The value of a growing number of firms in knowledge intensive activities is determined by the value of its IP, thus the importance of patenting and the use of patent data as a good indicator of difference in inventive activity across firms (Griliches, 1990). Despite its weaknesses, critics of the use of patents have not been able to provide better measures. Numerous papers have been published which support the use of patent data as an output indicator of technological innovation in economic studies (Narin et al, 1987; Brouwer and Kleinknecht, 1999; Kortum and Lerner, 1999; Acs et al, 2002). In particular, "patents filed" has been shown to be a reliable leading indicator of technological innovation.

Venture Data

Venture data were sourced and compiled from Thomson VentureXpert™ throughout the VC investment cycle (from initial selection to exit) including total venture capital invested, M&A and IPO exit value and multiple prior to exit. VentureXpert dataset also provides detailed company information including sectoral data (major industry group, sectoral subgroup). VentureXpert is a proprietary database of Venture Economics, which is a division of Thomson Financial. Venture Economics receives quarterly reports on portfolio holdings from more than 1000 venture capital organizations and major institutional investors. The information includes several data points about the portfolio companies including, among other things, a designation of the type of investment, name and location of the portfolio firm, date and amount of investment and the industry in which the firm competes. Due to its richness and reliability, VentureXpert has been extensively used in venture capital research. It contains the official database for the U.S. National Venture Capital Association.

Patent Data

Patent data were sourced from NBER-USPTO (Hall et al., 2001) supplemented by Thomson Delphion™ datasets to matched patent characteristics for VC-backed technology firms which exited via an IPO or M&A. The main NBER dataset extends from January 1, 1963 through December 30, 1999 (37 years), and includes all the utility patents granted during that period, totaling 2,923,922 patents; this dataset is referred as **PAT63_99**. In addition, the NBER **CONAME** file lists company names and associated assignee identifier. The patent data themselves were procured directly from the U.S. Patent Office. Where the firm names shown in VentureXpert and NBER were similar but not identical, judgements were based on city/state designations and technology area.

VentureXpert-NBER Data Matching

Technology venture company names from VentureXpert were matched with those of the NBER-USPTO patent database. The search process relies heavily on the original USPTO's coding of assignee names. Stata's *reclink* facility was used to perform an automated match of VentureXpert and NBER-USPTO data by assignee name. This resulted in a matching yield of less than 50%. Remaining assignee names were matched through a time-consuming investigation based on multiple lines of evidence (e.g. location, time, sector code, patent code matching, etc). For each unmatched firm in the dataset, the Delphion database on issued U.S. patents and published applications was searched by hand using company name, location, sector code along with common abbreviations and variations in the spelling of companies' names. "Weak" matches were verified by inspecting the inventor names, address information and the content of patent abstracts from Delphion. It is believed that this procedure captured all patent applications and issued patents for which a given firm was the assignee. But it is possible that some patents controlled by the firms in this sample were not captured in this search. Patent applications filed after the exit date were dropped from the resulting dataset. Data were uploaded in Stata 11, a full-featured statistical program for Windows, and all string and date variables were encoded prior to statistical treatment and analysis.

Variables

Several variables were used for this study but only a small subset was required to test hypotheses in this paper. They are as follows:

1. Three dependent variables:
   a. *investment:* Total (known) VC Amount Invested in million$ prior to exit
   b. *value:* Exit Value in million$
   c. *multiple:* Exit Multiple (Ratio of Exit Value/Total VC Investment)

2. One main independent variable:

   a. *p:* Dichotomous variable indicating patenting activity (0= no patenting; 1= patenting)
   b. *patcount:* Variable indicating the total number of patents filed prior to exit

3. Three control variables:
   a. *sector:* Company Technology Sector (level-2 fixed effects)
      a. biotechnology
      b. communications
      c. computer hardware
      d. computer software
      e. internet
      f. medical/health
      g. semiconductor/electronics
   b. *year:* Exit Year (1980 to 2000 for M&A or IPO)
   c. *type:* Exit Type (0= M&A; 1= IPO)

4. Other variables were primarily used to perform data matching and management operations.

Figure 1 depicts model variables in relation to tested hypotheses.

5. Results

Summary Statistics

The sample of 1504 VC-backed TBFs filed a total of 4261 patents prior to exiting over the study period. The sectoral distribution of venture capital exits and patents filed (prior to exit) over the study period is depicted in Table 1. Results show that IPO exits were found in all technology sectors over the study period with no sector representing less than 10% (i.e. computer hardware) or more than 20% (i.e. computer software) of overall IPO exits. Sectoral patenting rates, however, varied more widely for firms which exited via an IPO ranging from a low of 3% (i.e. internet sector) to a high of 28% (i.e. semiconductor/electronics sector) of total patents filed over the study period. In contrast, M&A exits were found to be relatively under-represented in some technology sectors (biotechnology: 7%; internet and semiconductor/electronics: 8%) and largely over-represented in others (i.e. computer software: 32%). Similarly, sectoral patenting rates varied very widely for firms which exited via M&A with a low of 0.2% (i.e. internet sector) to a high of 36% (i.e. semiconductor/electronics sector) of total patents filed over the study period.

An examination of the temporal distribution of venture capital exits and patents filed (prior to exit) in Table 2 reveals a gradual, albeit cyclical, increase in VC-backed technology IPOs, M&A and patenting activity over the study period. Total exits ranged from a low of 13 (1%) in 1982 to a high of 284 (19%) in 1999, the last year of the study. Similarly, total number of filed patents ranged from 19 (0.5%) in 1984 to a high of 742 (17%) in 1996. The absence of M&A exits prior to 1985 in our sample reflects the primary focus of Thomson's VentureXpert on VC-backed IPOs at the time.

However, the total number of reported M&A exits in the last three years exceeded the number of reported IPO exits in spite of a buoyant financial market which peaked in March 2000 ("internet bubble").

Firms (543) which exited via M&A filed 1144 patents whilst firms (961) exited via an IPO filed 3117 patents prior to exit. The average number of patents filed by firms which exited via an IPO (3.2) was 50% higher than for firms which exited via M&A (2.1). This difference can be broken down in two components: patenting rate and patent count. The difference in sectoral patenting rates between exit routes is graphically depicted in Figure 2. Fifty two percent (52%) of firms which exited via an IPO were engaged in patenting whilst only 33% of firms which exited via M&A were. Except for the semiconductor/electronics sector, this difference in patenting rates appears to be persistent across all sectors. However sectoral patent count for firms engaged in patenting, depicted in Figure 3, does not seem to differ greatly between exit routes. The mean patent count of VC-backed which exited via an IPO or M&A stood at 6.3 patents filed per patenting firm. The p-values of two-sample t tests with unequal variances (*Welch's t* tests) in Table 3 confirmed that, except for the semiconductor & electronics sector, the mean patenting rate of firms which exited via an IPO was significantly higher (at the 5% significance level or better) than for firms which exited via M&A. Thus, hypothesis 1 is accepted and we conclude that firms endowed with a technological resource (proxy by patenting) are more likely to be associated with the favoured and more profitable IPO exit route. However, the p-values of two-sample t tests with equal variances in Table 4 show that once firms engaged in patenting activity they did not significantly differ in patent count, implying comparable innovation intensity of patenting firms exiting via an IPO or M&A. More sophisticated regression models are required to test what relationships hold true between technological innovation and venture capital exit performance when controlling for sectoral and temporal effects as well as exit route.

Regression Analysis

The dataset contains 1504 observations in total. Because the 1504 observations represent several sectors however the usual assumptions of OLS and other common statistical methods do not apply. Instead models with more complex error specifications are required, allowing for both unit-specific and individual-observation disturbances.

The i.i.d. (independent and identically distributed) errors assumption is unlikely for panel data where the observations consist of the same units measured repeatedly. A more plausible panel-data model included two error terms. One is common to each of the i units, but differs between units (u_i). The second is unique to each of the i, j observations (e_{ij}). Units are defined as sectors and sectoral panels are treated with total VC investment, exit value and exit multiple as dependent variable y_{ij} and patenting and patent count as independent variables *patentingt*$_{ij}$ and *patcount*$_{ij}$ together with the two variables *year*$_{ij}$ to *type*$_{ij}$ to control for exit year and exit route, respectively.

$$\boldsymbol{y_{ij} = \beta_0 + \beta_1 patenting_{ij} + \beta_2 patcount_{ij} + \beta_3 year_{ij} + \beta_4 type_{ij} + u_i + e_{ij}}$$

i level-2 units
j level-1nested observations

In short, panel data are a blessing as they provide more informative data, more variability (e.g. sectoral effects), with less collinearity among variables, more degree of freedom and more efficiency. The model however is specified in "reduced form" because data on endogenous variables such as the amount of total non-VC capital received per unit of patented innovation for the financed technology-based firms was not available.

A two-level regression model accounting for the potential sectoral factors of innovation was fitted. It is a two-level fixed-effects (within) regression model on seven sectoral data panels, with year and type control variables (and robust Huber-White sandwich variance estimator[8]).

Results from the multilevel regression model are summarised in Table 5. However, before analyzing results and drawing hasty conclusions, the assumptions of the multilevel linear models must first be tested to ensure that they are not violated. As in multiple regression analysis, residual plots can be used to test model assumptions. The assumptions that need be examined in the multilevel linear models for VC investment, exit value and exit multiple are the assumptions of *normality*, *linearity*, *homoscedasticity* and *multicollinearity.*

Normality

Because the variances of the residual estimates depend on the value of the fixed coefficients, it is common to 'standardise' the residuals by the appropriate standard errors. A standardised normality plot can then be used to check the normality assumption of firm-level (i.e. level-one e_{ij}) residuals. The standardised residuals are plotted against a theoretical normal distribution in such a way that the points should form a straight line. Results, plotted at the top of Figure 4, indicate that the log transformations of response variables under investigation display an approximate normal distribution of residuals.

---

[8] The Huber-White sandwich variance estimator is a robust variance estimate that adjusts for within-cluster correlation. Robust variances give accurate assessments of the sample-to-sample variability of the parameter estimates even when the model is misspecified. Huber-White standard errors, or heteroscedasticity-consistent standard errors, were used to allow the fitting of models containing heteroskedastic residuals.

Linearity and Homoscedasticity

The assumption of linearity and homoscedasticity (i.e. constant finite variance) can be examined by applying a residual plot against predicted value of the response variable and using the fixed part of the multilevel regression for the prediction. The residual plots at the bottom of Figure 4 show the scatter of residuals around the predicted line. The plotted residual values of all response variables confirm the assumptions of linearity and homoscedasticity as residuals are evenly distributed around the predicted line and show no significant patterns indicating the presence of non-constant variances. Moreover, Huber-White standard errors, or heteroscedasticity-consistent standard errors, are used to allow the fitting of the fixed-effects models that may contain heteroscedastic residuals between sectoral panels (u_i).

Multicollinearity

Multicollinearity exists when two or more independent variables in a multiple regression model are highly correlated. This may result in the fixed-effects coefficient estimates $\hat{\beta}_i$ to change erratically in response to small changes in the model or the data. Although multicollinearity does not reduce the predictive power or reliability of the model as a whole, it affects calculations regarding individual predictors. Fortunately, the variance inflation factor (VIF) helps detect the presence of multicollinearity. The VIF factor for $\hat{\beta}_i$ with the following formula:

$$\mathrm{VIF} = \frac{1}{1 - R_i^2}$$

Where $R^2{}_i$ is the coefficient of determination of the regression equation. The magnitude of multicollinearity is determined by considering the size of the VIF($\hat{\beta}_i$). A common rule of thumb is that if VIF($\hat{\beta}_i$) > 5 then multicollinearity is high. Table 5 shows that the mean VIF for the multilevel models was 1.15 with no VIF($\hat{\beta}_i$) exceeding 1.25 (i.e. β_1 for patenting). This means that the standard error is 12% larger (i.e. $\sqrt{\mathrm{VIF}(\hat{\beta}_i)}$) than it would be if the patenting variable was uncorrelated with other independent variables in the equation. Thus, we conclude that multicollinearity is negligible. All key conditions of the multilevel linear regression model are met.

Results in Table 5 show that multilevel fixed-effects regression models for VC investment, exit value and exit multiple are all significant at the 1% significance level (Pr>F= .000). In particular, models for VC investment and exit value provide a very good fit (i.e. overall R^2), explaining 18% and 29% of the total variance. The positive VC investment regression's coefficients β_1 for patenting and β_2 for patent count (significant at the 10% significance level) means that total VC investment received by technology firms is positively influenced by patenting and patenting intensity prior to exit, after controlling for exit route, sectoral and temporal effects. The positive exit value regression's coefficient β_2 for patent count (significant at the 1% significance level) means that the exit value of technology firms is positively influenced by patenting intensity, after controlling for exit route, sectoral and temporal effects. Hypotheses H2 and H3 are accepted. However, the negative exit multiple regression's coefficient β_1 for patenting (significant at the 10% significance level) means that the exit multiple of technology firms is negatively influenced by patenting, after controlling for exit route, sectoral and temporal effects. Thus, hypothesis H4 is rejected. As expected, exit route is an important and significant (at the 1% significance level) control variable for all determinants of venture capital exit performance under investigation: total VC investment, exit value and exit multiple. Exit year is also an important and significant (at the 1% significance level) control variable for VC investment and exit value but not exit multiple which has been relatively constant over the study period. Figure 5 illustrates how fitted VC investment and exit value have risen steadily from 1980-2000 for TBFs which exited via an IPO or M&A. Finally, the intraclass correlation ρ indicates that strong sectoral fixed effects u_i contributes to explain large fractions of the variance, especially in the exit value multilevel regression model where sectoral fixed effects explained nearly 11% of the total variance.

6. Discussion and Conclusion

The paper contributes to two important strands of the literature. First it expands the literature on venture capital by showing that technology firms, characterised by higher innovation intensity, are rewarded with larger investment from VC investors and superior exit value. However, innovation failed to positively influence the exit multiple of VC-backed technology firms. Whilst average VC investment and exit value have increased steadily over time, exit time has been remarkably stable. Previous research has shown that technological innovation (proxy by patents) can act as an important quality signal which reduces the risk of adverse selection and attracts more VC investors and larger investment (Nadeau, 2010). However, the balance between investment, risk and return is a delicate one. The paper provides some evidence that VCs may be over-investing in innovative TBFs. This, in turn, can result in lower performance as higher exit values fail to keep up with higher VC investments in innovative TBFs. Other studies have highlighted the relationship between patenting activity and the firm's performance, including number of rounds and total VC investment (Mann and Sager, 2007) in the software sector and the likelihood of attracting a prominent VC investor in the semiconductor sector (Hsu and Ziedonis, 2007). This paper, however, provides a novel contribution to venture capital research by establishing clear linkages between the technological innovation and exit performance of VC-backed technology firms across several technology sectors between 1980 and 2000 and throughout the whole venture capital cycle, from initial investment to exit.

As a contribution to the RBV literature the study findings reveal that unique (i.e. VRIS-compliant) technology resources, protected by patents, attract more VC investment and are associated with higher exit values. The favoured and more profitable IPO exit route was found to be associated with firms with technology resources. However, RBV did not explain why innovative firms endowed with unique technology failed to deliver competitive advantage and produce higher exit multiples and thus, adequately reward VC investors. The study highlights limitations of the RBV when applied to fast-changing entrepreneurial technology firms.

These results have important implications for entrepreneurial firms and venture capital practice. As a large-scale study of the patented innovations of technology firms that successfully managed to exit via an IPO or M&A results inform us of the good practices and dangers of innovation.

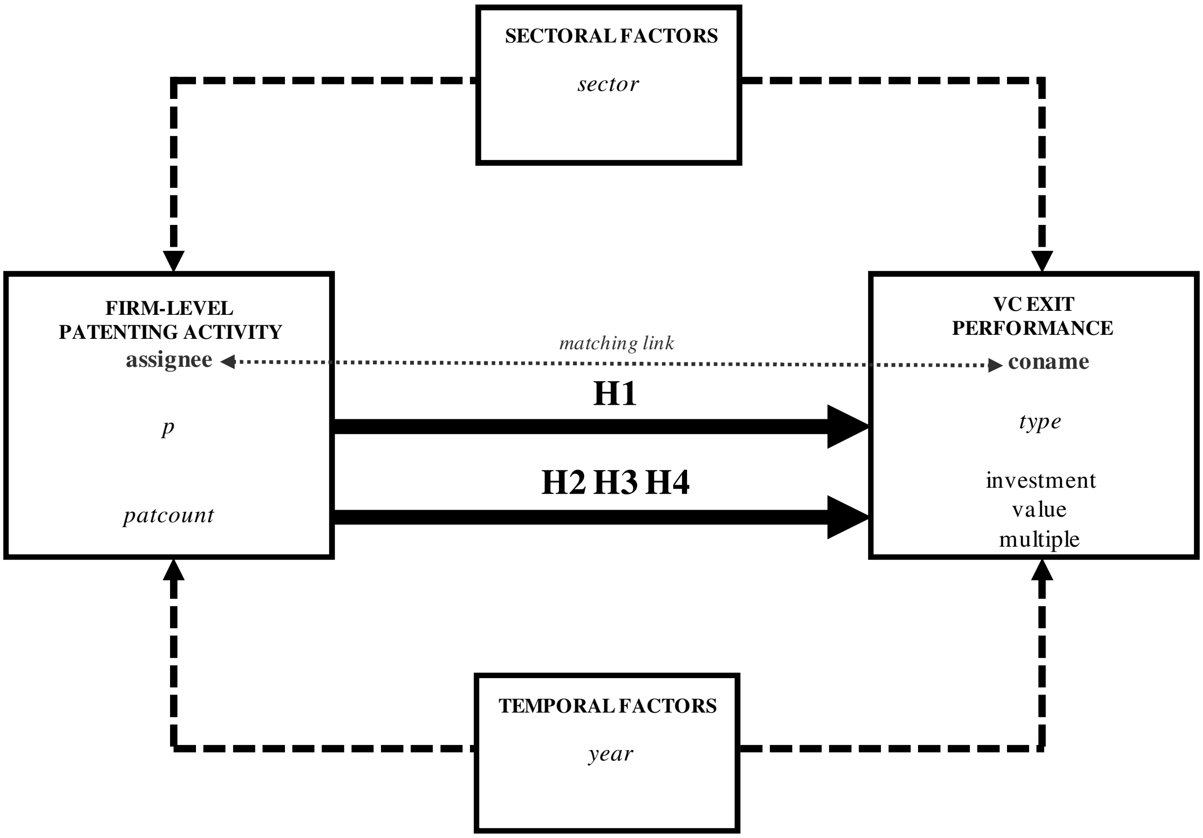
Results suggest that *technology-based firms* can benefit from innovation. The study findings show that innovation can improve firm's ability to attract larger VC investment which can be use to accelerate commercialisation, build a market advantage and distance competitors. Patents, by their very nature, provide owners with the right to exclude others from making, using, selling the patented invention for the term of the patent which is usually 20 years from the filing date. They buy time for the entrepreneurial venture to build the business and mitigate the risk of being outspent by well-resourced incumbents in the short term. Patented innovations are intangible assets which increase company valuation. They are associated with higher exit value and contribute to increasing shareholders' wealth.

Venture capital firms should consider patented innovation as an important and significant quality signal which can help with investment activities and contribute to value creation. Technology firms with patented innovations and more likely to exit via an IPO, a highly desirable and profitable outcome expected from limited partners investing in VC funds. Previous studies have shown that bringing companies public can influence fundraising and can indeed be a matter of survival for VC firms (Gompers et al., 1996). TBFs with patented innovations are associated with higher exit value, irrespective of exit route. However, results also show that TBFs engaged in patenting activity are also associated with lower exit multiple, a stark reminder to VCs that they must exert caution and keep investment in innovative TBFs in balance with expected return.

This study, however, has several limitations and further work is required. First, whilst this research focuses on patented inventions many technological innovations are not patented. New research methods are needed to collect reliable data on different types of innovation relevant to young technology firms. The net benefits of alternative measures of technological innovation at different stages in the venture capital cycle represent an understudied yet promising avenue for further study. Second, all patents are not created equal. Patent characteristics such as quality or importance need be studied in detail to enable a better understanding of the influence of patenting activity on venture capital investment performance. Third, the study focused on the analysis of time-invariant variables and, other than exit time, temporal aspects of patented innovation were neglected. Static RBV approaches have been criticised for relegating causality to a "black-box", calling for a more rigorous RBV answering causal "how" questions, and incorporating the temporal component (Priem and Butler, 2001). These temporal effects may be nested within regions and sectors, implying that more sophisticated controls for collinearity and endogeneity may require more advanced multilevel (3-level) mixed-effects modelling techniques. The mixed results obtained in this study suggest that a dynamic RBV of the technology-based firm is in order. Many unanswered questions need to be explored in future work.

Tables and Figures

Figure 1: Model Variables



Note: Constructed variables are shown in italics.

Figure 2: Pre-Exit Patenting Rates

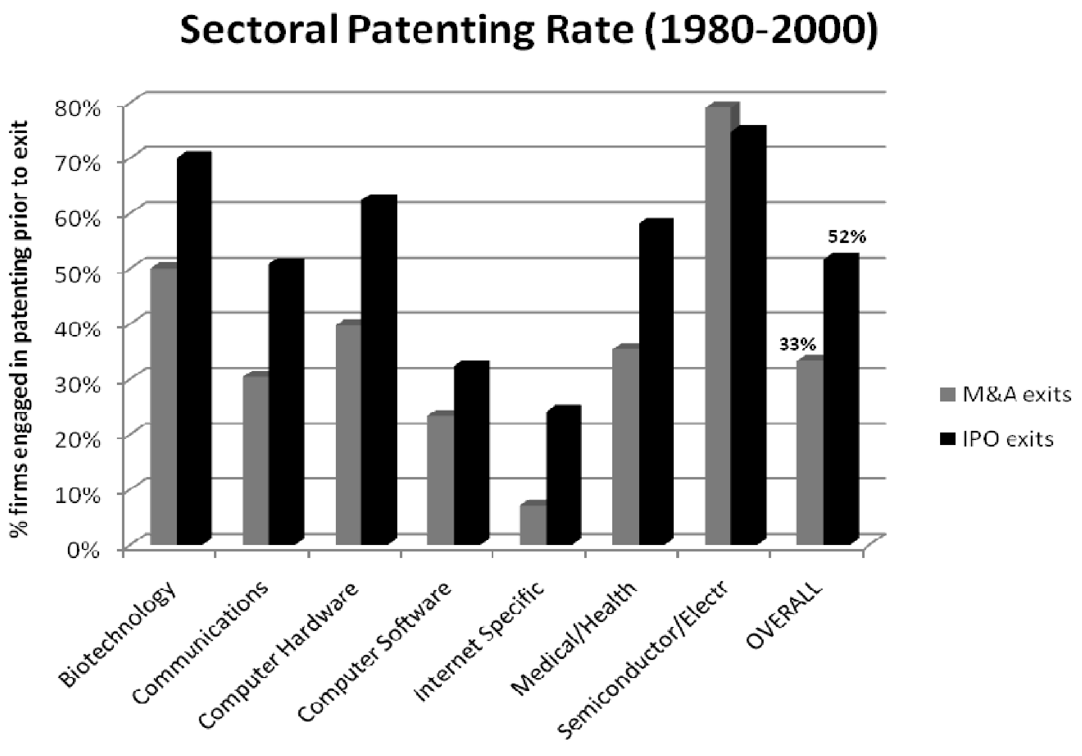


Figure 3: Pre-Exit Patent Count

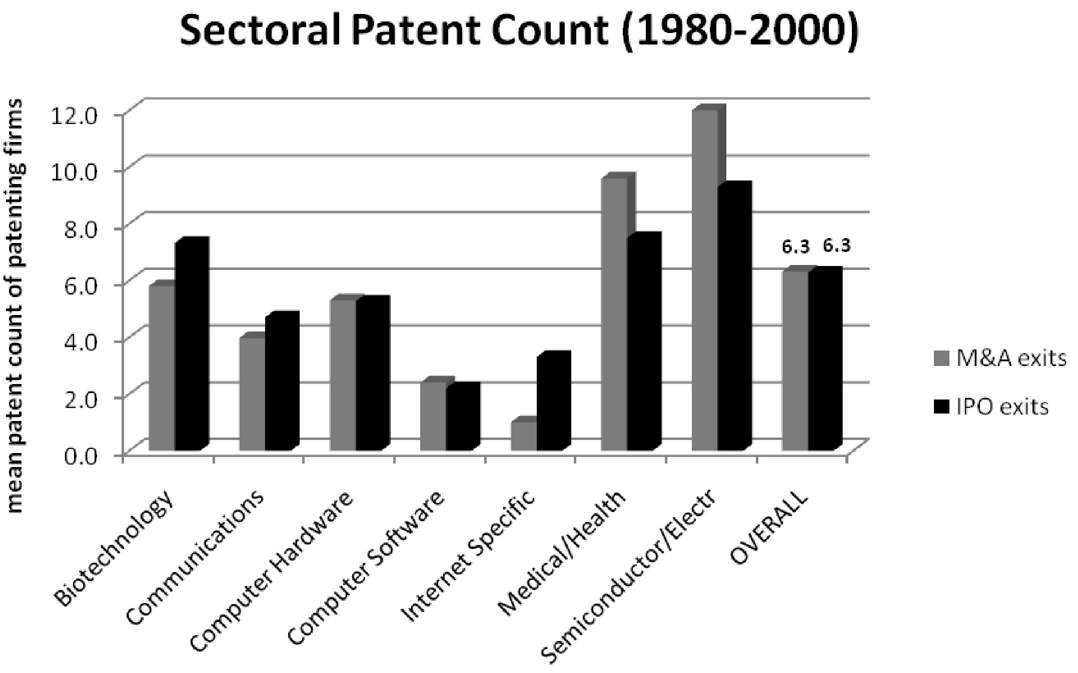


Figure 4: Multilevel Linear Regression Assumptions

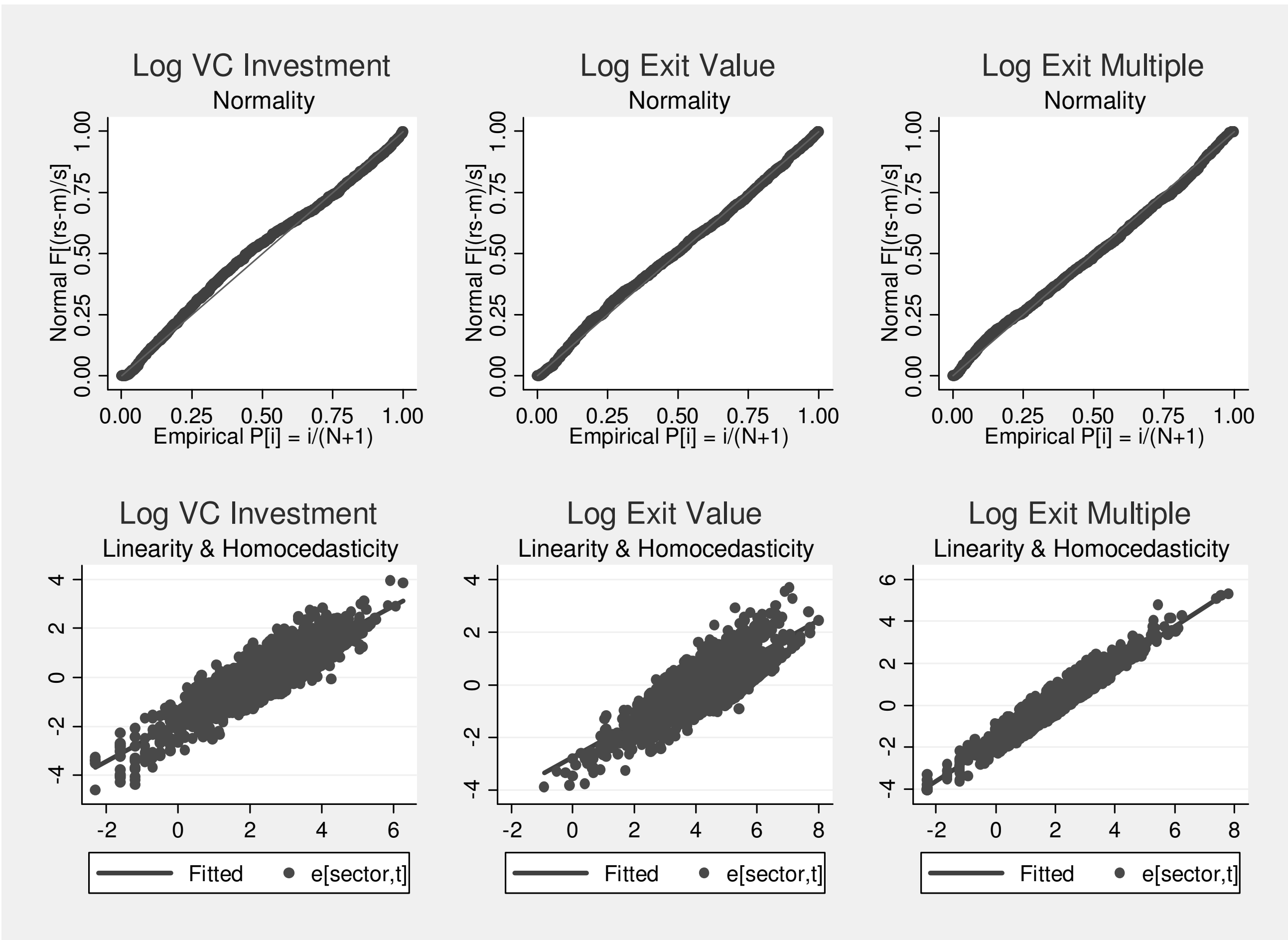


Figure 5: Fitted VC Investment and Exit Value by Exit Route

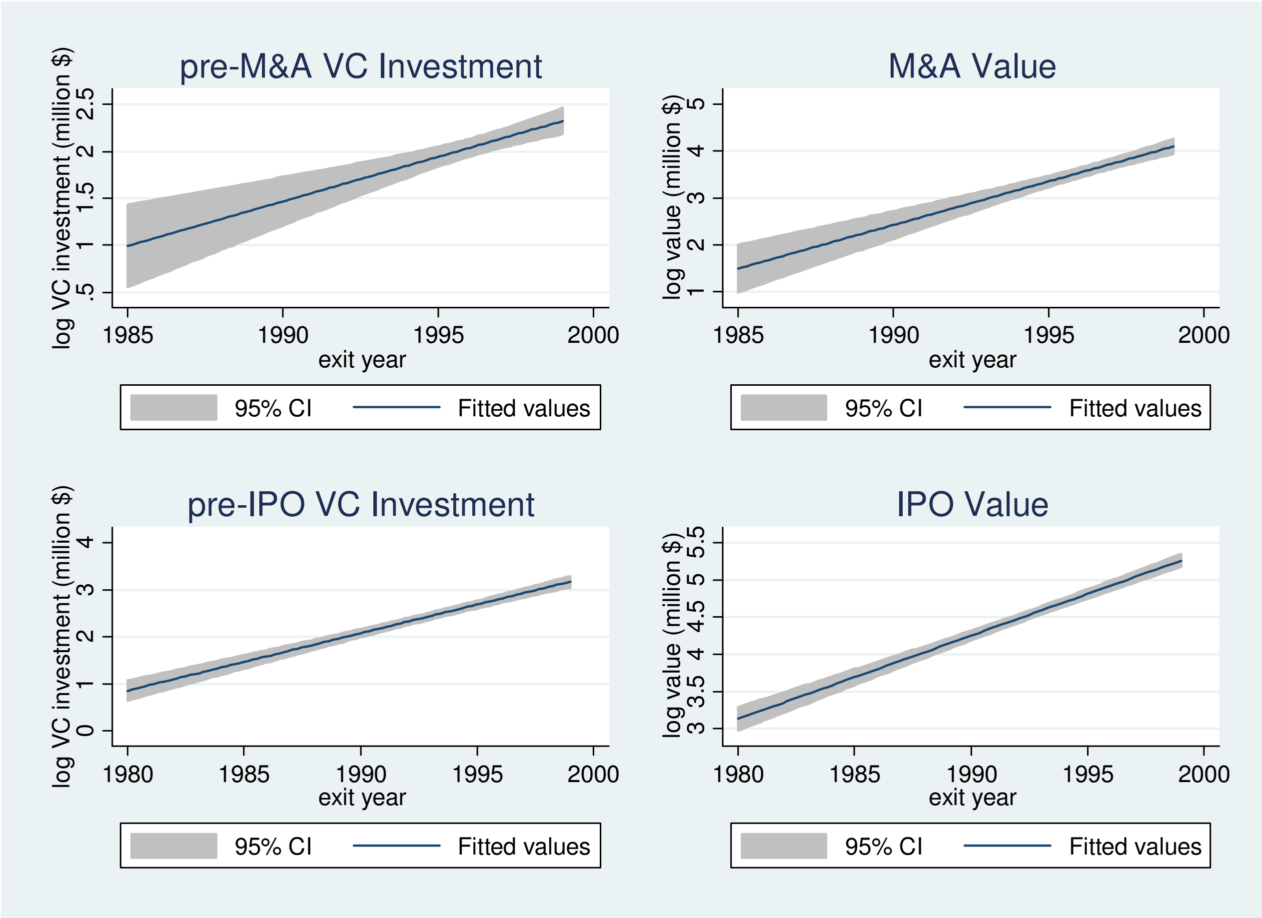


Table 1: Sectoral Distribution of Venture Capital Exits and Filed Patents (prior to exit)

TECHNOLOGY SECTOR	M&A EXITS	PATENT FILED	IPO EXITS	PATENT FILED	TOTAL EXITS	TOTAL PATENTS FILED
Biotechnology	38	110	117	600	155	710
Communications	102	123	122	293	224	416
Computer Hardware	63	133	93	305	156	438
Computer Software	176	98	192	136	368	234
Internet Specific	42	3	124	99	166	102
Medical/Health	79	268	186	806	265	1074
Semiconductor/Electr	43	409	127	878	170	1287
TOTAL	**543**	**1144**	**961**	**3117**	**1504**	**4261**

Table 2: Temporal Distribution of Venture Capital Exits and Filed Patents (prior to exit)

EXIT YEAR	M&A EXITS	PATENT FILED	IPO EXITS	PATENT FILED	TOTAL EXITS	TOTAL PATENTS FILED
1980	0	0	14	30	14	30
1981	0	0	16	23	16	23
1982	0	0	13	29	13	29
1983	0	0	45	103	45	103
1984	0	0	17	19	17	19
1985	2	156	13	3	15	159
1986	0	0	36	97	36	97
1987	3	3	28	59	31	62
1988	1	0	15	42	16	42
1989	3	10	23	72	26	82
1990	4	1	24	75	28	76
1991	2	4	58	163	60	167
1992	36	102	57	129	93	231
1993	33	78	69	369	102	447
1994	46	105	52	98	98	203
1995	50	61	76	404	126	465
1996	57	105	129	637	186	742
1997	84	150	66	315	150	465
1998	99	192	49	129	148	321
1999	123	177	161	321	284	498
TOTAL	**543**	**1144**	**961**	**3117**	**1504**	**4261**

Table 3: Difference in Patenting Rates between VC Exit Routes

	M&A Exits			IPO Exits			Diff. Means
	Number of Observations	Mean	Standard Deviation	Number of Observations	Mean	Standard Deviation	p-value Pr(IPO>M&A)
Biotechnology	38	0.50	0.51	117	0.71	0.46	0.017
Communications	102	0.31	0.46	122	0.51	0.50	0.000
Computer Hardware	63	0.40	0.49	93	0.62	0.49	0.003
Computer Software	176	0.23	0.42	192	0.32	0.47	0.027
Internet Specific	42	0.07	0.26	124	0.24	0.43	0.001
Medical/Health	79	0.35	0.48	186	0.58	0.49	0.000
Semiconductor/Electr	43	0.79	0.41	127	0.75	0.44	0.282
TOTAL	**543**	**0.33**	**0.47**	**961**	**0.52**	**0.50**	**0.000**

Table 4: Difference in Patent Count between VC Exit Routes (for patenting firms)

	M&A Exits			IPO Exits			Diff. Means
	Number of Observations	Mean	Standard Deviation	Number of Observations	Mean	Standard Deviation	p-value Pr(IPO>M&A)
Biotechnology	19	5.79	5.02	82	7.32	10.23	0.264
Communications	31	3.97	4.55	62	4.73	11.00	0.357
Computer Hardware	25	5.32	9.94	58	5.26	9.52	0.511
Computer Software	41	2.39	2.42	62	2.19	3.02	0.636
Internet Specific	3	1.00	0.00	30	3.30	3.61	0.143
Medical/Health	28	9.57	9.53	108	7.46	9.49	0.852
Semiconductor/Electr	34	12.03	23.43	95	9.24	10.85	0.820
TOTAL	**181**	**6.32**	**12.1**	**497**	**6.27**	**9.56**	**0.522**

Table 5: Multilevel Regression Results

Sectoral Data Panels	Venture Capital Exit Performance		
	Multilevel Fixed-effects (within) Regression (robust)		
	Log VC Investment	Log Exit Value	Log Exit Multiple
R-sq within	0.1535	0.2661	0.0613
R-sq between	0.7280	0.6308	0.0829
R-sq overall	0.1818	0.2917	0.0544
Mean VIF	1.15	1.15	1.15
Prob > F	0.0005***	0.0000***	0.0002***
Patenting *(β_1 coefficient, VIF=1.25)*	0.1492*	-	-0.1575*
Patent count *(β_2 coefficient,VIF=1.22)*	0.0168*	0.0133***	-
Exit year *(β_3 coefficient, VIF=1.13)*	0.1094***	0.0977***	-
Exit type *(β_4 coefficient, VIF=1.15)*	0.6758***	1.3455***	0.6567***
σ_u *(fixed effects)*	0.2462	0.3666	0.2584
σ_e *(standard errors)*	1.2102	1.0683	1.3000
ρ *(intraclass correlation[1])*	0.0397	0.1053	0.0380

*** 1% significance level, ** 5% significance level, *10% significance level

[1] ICC is the fraction of variance due to sectoral fixed effects *(u_i)*.

References

Acs ZJ, Varga A. 2002. Geography, endogenous growth, and innovation. *International Regional Science Review* **25**(1): 132-148.

Admati AR, Pfleiderer P. 1994. Robust Financial Contracting and the Role of Venture Capitalists. *Journal of Finance* **49**(2): 371-402.

Amit R, Brander J, Zott C. 1998. Why do venture capital firms exist? Theory and Canadian evidence. *Journal of Business Venturing* **13**(6): 441-466.

Archibugi D, Pianta M. 1996. Measuring technological change through patents and innovation surveys. *Technovation* **16**(9): 451-468.

Arrow KJ. 1959. *Economic Welfare and the Allocation of Resources for Invention*. The RAND Corporation: Santa Monica, CA.

Barney J. 1991. Firm resources and sustained competitive advantage. *Journal of Management* **17**(1): 99-120.

Bascha A, Walz U. 2001. Convertible securities and optimal exit decisions in venture capital finance. *Journal of Corporate Finance* **7**(3): 285-306.

Baum JAC, Silverman BS. 2004. Picking winners or building them? Alliance, intellectual, and human capital as selection criteria in venture financing and performance of biotechnology startups. *Journal of Business Venturing* **19**(3): 411-436.

Brouwer E, Kleinknecht A. 1999. Innovative output, and a firm's propensity to patent. An exploration of CIS micro data. *Research Policy* **28**(6): 615-624.

Cantwell JA, Santangelo GD. 2008. *The Restructuring of Dynamic Capabilities Through Corporate Expansion*. Social Science Research Network (SSRN).

Chemmanur TJ, Fulghieri P. 1999. A theory of the going-public decision. *Review of Financial Studies* **12**(2): 249-279.

Clarysse B, Knockaert M, Lockett A. 2004. How do Early Stage High Technology Investors select their investments? Gent, Gate2Growth Academic Network.

Cochrane JH. 2005. The risk and return of venture capital. *Journal of Financial Economics* **75**(1): 3-52.

Cumming DJ, MacIntosh JG. 2003. A cross-country comparison of full and partial venture capital exits. *Journal of Banking & Finance* **27**(3): 511-548.

Das SR, Jagannathan M, Sarin A. 2003. The Private Equity Returns: An Empirical Examination of The Exit of Venture Backed Companies. *Journal of Investment Management* **1**(1): 1-26.

EIU. 2007. *Innovation: Transforming the way business creates.* The Economist Intelligence Unit.

European Commission DR. 2007. *Key Figures 2007 on Science, Technology and Innovation: Towards a European Knowledge Area.* European Commission Directorate General Research.

Geroski P, Machin S, Vanreenen J. 1993. The Profitability of Innovating Firms. *Rand Journal of Economics* **24**(2): 198-211.

Giot P, Schwienbacher A. 2007. IPOs, trade sales and liquidations: Modelling venture capital exits using survival analysis. *Journal of Banking & Finance* **31**(3): 679-702.

Global_Insight. 2007. The Economic Importance of Venture Capital Backed Companies to the U.S. Economy. National Venture Capital Association (ed.) Fourth edition.

Gompers P, Kovner A, Lerner J, Scharfstein D. 2008. Venture capital investment cycles: The impact of public markets. *Journal of Financial Economics* **87**: 1-23.

Gompers P, Lerner J. 2004. *The Venture Capital Cycle* (2nd ed.). MIT Press: Cambridge, Mass.

Gompers PA. 1995. Optimal Investment, Monitoring, and the Staging of Venture Capital. *Journal of Finance* **50**(5): 1461-1489.

Gompers PA. 1996. Grandstanding in the venture capital industry. *Journal of Financial Economics* **42**(1): 133-156.

Granstrand O. 1998. Towards a theory of the technology-based firm. *Research Policy* **27**(5): 465-489.

Granstrand O. 1999. *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*. Edward Elgar: Cheltenham.

Grant RM. 1996. Toward a knowledge-based theory of the firm. *Strategic Management Journal* **17**: 109-122.

Griliches Z. 1981. Market Value, R&D, and Patents. *Economics Letters* **7**(2): 183-187.

Griliches Z. 1990. Patent Statistics as Economic Indicators – A Survey. *Journal of Economic Literature* **28**(4): 1661-1707.

Guler I. 2007. Throwing good money after bad? Political and institutional influences on sequential decision making in the venture capital industry. *Administrative Science Quarterly* **52**(2): 248-285.

Hall BH, Jaffe AB, Trajtenberg M. 2001. *The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools.* NBER Working Paper Series. National Bureau of Economic Research (NBER): Cambridge, MA.

Hege U, Palomino F, Schwienbacher A. 2006. *Venture Capital Performance: the Disparity Between Europe and the United States.* Social Science Research Network (SSRN).

Hitt MA, Ireland RD, Lee HU. 2000. Technological learning, knowledge management, firm growth and performance: an introductory essay. *Journal of Engineering and Technology Management* **17**(3-4): 231-246.

Hsu DH. 2007. Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy* **36**(5): 722-741.

Huyghebaert N, De Gucht LMV 2004. Incumbent strategic behavior in financial markets and the exit of entrepreneurial start-ups. *Strategic Management Journal* **25**(7): 669-688.

Kaplan SN, Stromberg P. 2003. Financial contracting theory meets the real world: An empirical analysis of venture capital contracts. *Review of Economic Studies* **70**(2): 281-315.

Kortum S, Lerner J. 1999. What is behind the recent surge in patenting? *Research Policy* **28**(1): 1-22.

Kortum S, Lerner J. 2000. Assessing the contribution of venture capital to innovation. *Rand Journal of Economics* **31**(4): 674-692.

Laperche B, Uzunidis D. 2008. *Powerful finance and innovation trends in a high-risk economy*. Palgrave Macmillan: Basingstoke.

Makri M, Junkunc M, Eckhardt J. 2007. *Technological Diversification, Cumulativeness and Venture Capital Exit: M&A Versus IPO.* Social Science Research Network (SSRN).

Mann RJ, Sager TW. 2007. Patents, venture capital, and software start-ups. *Research Policy* **36**(2): 193-208.

Metrick A. 2007. *Venture Capital and the Finance of Innovation*. Wiley: New York.

Murray F, O'Mahony S. 2007. Exploring the foundations of cumulative innovation: Implications for organization science. *Organization Science* **18**(6): 1006-1021.

Nadeau P. 2010. Venture Capital Investment Selection: Do Patents Attract Investors? *Strategic Change* **19**(7-8): 325-342.

Narin F, Noma E, Perry R. 1987. Patents as Indicators of Corporate Technological Strength. *Research Policy* **16**(2-4): 143-155.

O'Sullivan M. 2006. Finance and Innovation. In *The Oxford Handbook of Innovation.* Fagerberg J, Mowery DC, Nelson RR (eds.) First ed., Oxford University Press: Oxford.

Penrose ET. 1959. *The Theory of the Growth of the Firm*. B. Blackwell: Oxford.

Porter ME. 1979. How Competitive Forces Shape Strategy. *Harvard Business Review* **57**(2): 137-145.

Porter ME. 1985. *Competitive Advantage : Creating and sustaining superior performance*. Free Press: London.

Priem RL, Butler JE. 2001. Is the resource-based "view" a useful perspective for strategic management research? *Academy of Management Review* **26**(1): 22-40.

Romer PM. 1986. Increasing Returns and Long Run Growth. *Journal of Political Economy* **94**(5): 1002-1037.

Romer PM. 1990. Endogenous Technological Change. *Journal of Political Economy* **98**(5): S71-S102.

Spender JC. 1996. Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal* **17**: 45-62.

Stuck B, Weingarten M. 2005. How venture capital thwarts innovation. *Ieee Spectrum* **42**(4): 50-55.

Thornhill S, Amit R. 2003. Learning about failure: Bankruptcy, firm age, and the resource-based view. *Organization Science* **14**(5): 497-509.

Wernerfelt B. 1984. A Resource-based View of the Firm. *Strategic Management Journal* **5**(2): 171-180.

Woodward SE, Hall RE. 2003. *Benchmarking the Returns to Venture.* Sand Hill Econometrics.

Zingales L. 2000. In search of new foundations. *Journal of Finance* **55**(4): 1623-1653.

Bibliographic Note

Pierre Nadean is a Lecturer at Birkbeck University of London. He was previously General Partner at Frontiers Capital, an early-stage venture capital firm investing in information and communications technology.

Correspondence to:
Pierre Nadeau
Birkbeck University of London
School of Business, Economics and Informatics
Malet Street, Bloomsbury
London WC1E 7HX
United Kingdom
Email: p.nadeau@mbs.bbk.ac.uk